result given indicates that when carbon is added by the cementation process, the phosphide, when in large quantity, is thrown, not only out of solution, but escapes entirely out of the metal as a liquid eutectic leaving a constant residuum behind. A method is described by which phosphorus compounds in pig iron can be identified by means of the microscope. This consists in simply heating the polished surfaces to about 300° C. for a few minutes, when each constituent takes a different oxidation tint. The iron acquires a sky-blue colour, the carbide a red-brown and the phosphide compound a pale yellow. The coloured sections are of great beauty. Many results are given showing how the solid phosphide diffuses in solid iron, and showing that under suitable conditions well-formed crystals will grow in solid metal.

Mr. H. Bauerman's paper on iron and steel at the Universal Exhibition, Paris, 1900, was prepared mainly for the use of the members of the Institute visiting the Exhibition during the meeting. It contained a critical description of the more prominent metallurgical exhibits, and forms a valuable record of the condition of the metallurgical industry at the close of the century.

On September 19, the remaining papers on the programme were dealt with. Chief among these was that by Mr. E. F. Lange, on a new method of producing high temperatures. The principle underlying the process, which is the outcome of researches made by Dr. H. Goldschmidt of Essen, is not new, as it is based upon the heat energy developed by the chemical action of aluminium upon oxygen, or rather that between aluminium and certain metallic oxides. The practicability of the process was clearly shown by the welding together during the meeting of two short lengths of heavy girder rails. The method not only opens up a new field for aluminium but also promises to be of considerable importance in engineering work. In the discussion Sir William Roberts-Austen pointed out the extreme precision with which the reduction took place, and Sir Lowthian Bell dwelt on the value of the process if it should prove that carbonless iron could be obtained by it for electrical purposes.

The paper by Mr. A. L. Colby, of Bethlehem, United States, on American standard specifications and methods of testing iron and steel, embodied the results of over a year's work by a committee of American experts, conducted with a view to the adoption of international standards. Some of the specifications were criticised by Mr. R. A. Hadfield. The engineer, he thought, was encroaching on the field of the metallurgist. Interesting contributions to the discussion were made by Mr. C. P. Sandberg and by Dr. Dudley, of Pennsylvania.

In a paper on the influence of aluminium on the carbon in cast-iron, Mr. G. Melland and Mr. H. W. Waldron gave the results of an elaborate research in which they endeavoured to determine the amount of aluminium which is necessary to produce the maximum separation of graphite in a white pig-iron as free as possible from silicon and other impurities, and to ascertain, by casting every melting both in sand and in chill moulds, the effect produced by slow and rapid cooling upon the mode of existence of the carbon in the metal with amounts of aluminium varying from 0·02 to 12 per cent.

In the paper by Mr. Louis Katona, of Resicza, Hungary, the various disadvantages of the rolling-mills now in use were discussed, and suggestions were made for obviating them with a view to increasing the output and lessening the fuel consumption.

In a lengthy paper on the constitution of slags, which was taken as read, Baron H. von Jüptner discussed iron slags from a modern point of view, and described the varying reactions which take place between them and iron. The slags considered are divided into three groups—silicate slags, phosphate slags and oxide slags. The results of the investigation tend to show that slags should be regarded as solutions, and not as complicated chemical compounds.

The "phase-rule" of Gibb has served as a guide to the authors of two well-reasoned papers of great scientific interest—one on iron and steel from the point of view of the phase doctrine, by Prof. Bakhuis-Roozeboom, of Amsterdam, and the other on the present position of the solution theory of carburised iron, by Dr. A. Stansfield. The phase rule says in effect that in a system such as that of the carburised irons, in which two distinct substances (carbon and iron) are involved, but in which certain forms or phases of carbon or iron, or carbon-iron solution, or carbon-iron compound, are present, no more than two of these phases can exist in equilibrium with each other at a particular temperature. In the case of a solution of salt in water, this would mean that there could only be salt and ice and solution together at a particular temperature (the eutectic temperature), and that at any other temperature there could only be ice and solution or salt and solution (at temperatures above the eutectic), or ice and salt (at temperatures below the eutectic). In the case of a salt solution this is quite evident, but the value of the phase rule is that we can apply it with equal confidence in cases where we do not, to begin with, know the answer to our question. Applying the rule to the case of solid carburised iron at temperatures above that of all the known allotropic charges—we have the four possible substances of iron, graphite, cementite and solid solution of carbon (either graphite or cementite) in pig-iron. The rule states that only two of these can in general exist permanently together. The general conclusions to be drawn from Dr. Stansfield's researches are:—

(1) That carbon is less soluble in iron when presented in the form of graphite than when presented in the form of cementite.

(2) That the apparent reversal of this in steel is due partly to the absence of nuclei of graphite on which further deposits might take place; partly to the length of time required for the separation of the graphite, involving, as it does, the gradual passage of carbon through the iron to reach the nuclei, and partly to the mechanical pressure which must oppose the formation of graphite in solid steel.

The meeting was brought to a close by a vote of thanks to the French authorities and societies, whose hospitality had been enjoyed, proposed by the president and seconded by Mr. W. Whitwell, president-elect. A vote of thanks to the president was proposed by Mr. Greiner, of Seraing, Belgium, and seconded by Mr. Nordenfelt. The social functions in connection with the meeting were of a very attractive character. They included an operatic entertainment organised by the Comité des Forges, a reception by the Commissioner-General and Mrs. Jekyll at the British Royal Pavilion, a banquet at the Hôtel Continental, a reception by Mr. E. Schneider in the Le Creusot pavilion, a reception at the Hôtel de Ville by the president of the Municipal Council, and a reception on September 24 by the Minister of Public Works.

THE BRADFORD MEETING OF THE BRITISH ASSOCIATION.

SECTION K.

BOTANY.

OPENING ADDRESS BY PROF. S. H. VINES, M.A., D.SC., F.R.S., PRESIDENT OF THE SECTION.

THERE has been considerable difference of opinion as to whether the present year marks the close of the nineteenth or the beginning of the twentieth century. But whatever may be the right or the wrong of this vexed question, the fact that the year-date now begins with 19, instead of with 18, suggests the appropriateness of devoting an occasion such as the present to a review of the century which has closed, as some will have it, or, in the opinion of others, is about to close. I therefore propose to address you upon the progress of Botany during the nineteenth century.

I am fully conscious of the magnitude of the task which I am undertaking, more especially in its relation to the limits of time and space at my disposal. So eventful has the period been that to give in any detail an account of what has been accomplished during the last hundred years would mean to write the larger half of the entire history of Botany. This being so, it might appear almost hopeless to attempt to deal with so large a subject in a Presidential Address. But I trust that the very restrictions under which I labour may prove to be rather advantageous than otherwise, inasmuch as they compel me to confine attention to what is of primary importance, and thus to give special prominence to the main lines along which the development of the science has proceeded.

Statistics.

We may well begin with what is, after all, the most fundamental matter, viz. the relative numbers of known species of plants at the beginning and at the end of the century. It might appear that the statistics of plants was a subject susceptible of very simple treatment, but unfortunately this is not the case. It must be remembered that a "species" is not an invariable standard unit, like a pound or a pint, but that it is an idea dependent upon the subjectivity of individual botanists. For instance, one botanist may regard a certain number of similar plants as all belonging to a single species, whilst another may find the differences among them such as to warrant the distinction of as many species as there are plants. It is this inevitable variation in the estimation of specific characters which renders it difficult to deal satisfactorily with plants from the statistical point of view. However, the following figures may be regarded as giving a fair idea of the increase in the number of "good" species of living plants.

It is generally stated that about 10,000 species of plants were known to Linnæus in the latter half of the eighteenth century, of which one-tenth were Cryptogams; but so rapid was the progress in the study of new plants at that time that the first enumeration of plants published in the nineteenth century, the "Synopsis" of Persoon (1807), included as many as 20,000 species of Phanerogams alone. Turning now to the end of the century, we arrive at the following census, for which I am indebted mainly to Prof. Saccardo (1892) and to Prof. de Toni who has kindly given me special information as to the Algæ:—

Species of Phanerogams indicated in Bentham and Hooker's "Genera Plantarum" (Durand, "Index," 1888).

Dicotyledons	78,200
Monocotyledons	19,600
Gymnosperms	2,420
	100,220
Estimated subsequent additions (Saccardo) ...	5,011
Total Phanerogams ...	105,231

Species of Pteridophyta (indicated in Hooker and Baker's "Synopsis"; Baker's "New Ferns" and "Fern Allies").

Filicinæ (including Isoëtes), about	3,000
Lycopodinæ, about	432
Equisetinæ, about	20
Total Pteridophyta	3,452

Species of Bryophyta (Saccardo's Estimate).

Musci	4,609
Hepaticæ	3,041
Total Bryophyta	7,650

Species of Thallophyta.

Fungi (including Bacteria) (Saccardo) ...	39,663
Lichens (Saccardo)	5,600
Algæ (incl. 6000 Diatoms) (de Toni)... ...	14,000
Total Thallophyta	59,263

Adding these totals together—

Phanerogams	105,231
Pteridophyta	3,452
Bryophyta	7,650
Thallophyta	59,263
we have a grand total of	175,596

as the approximate number of recognised species of living plants.

These figures are sufficiently accurate to show how vast have been the additions to the knowledge of plants in the period under consideration, and they afford much food for thought. In the first place, they indicate how closely connected has been the growth of this branch of Botany with the exploration and opening-up of new countries which has been so characteristic a feature of the century. Again, no one can consider these figures without being struck by the disparity in the numbers of species included in the different groups; a most interesting topic, which cannot, however, be entered upon here. It must suffice to point out in a general way that the smaller groups represent families of plants which attain their numerical zenith in long past geological periods, and are now decadent, whilst the existing flora of the world is characterised by the preponderating Angiosperms and Fungi.

We may venture to cast a forward glance upon the possible future development of the knowledge of species. Various partial estimates have been made as to the probable number of existing species of this or that group, but the only comprehensive estimate with which I am acquainted is that of Prof. Saccardo (1892). He begins with a somewhat startling calculation to the effect that there are at least 250,000 existing species of Fungi alone, and he goes on to suggest that probably the number of species belonging to the various other groups would amount to 150,000; hence the total number of species now living is to be estimated at over 400,000. On the basis of this estimate it appears that we have not yet made the acquaintance of half the contemporary species; so that there remains plenty of occupation for systematic and descriptive botanists, especially in the department of Fungology. It is also rather alarming, in view of the predatory instincts of so many of the Fungi, to learn that they constitute so decided a majority of the whole vegetable kingdom.

In spite of the great increase in the number of known species, it cannot be said that any essentially new type of plant has been discovered during the century. So far as the bounds of the vegetable kingdom have been extended at all, it has been by the annexation of groups hitherto regarded as within the sphere of influence of the zoologists. The most notable instance of this has occurred in the case of the Bacteria, or Schizomycetes, as Naegeli termed them. These organisms, discovered by Leeuwenhoek 200 years ago, had always been regarded as infusorian animals until, in 1853, Cohn recognised their vegetable nature and their affinity with the Fungi. These plants have acquired special importance, partly on account of the controversy which arose as to their supposed spontaneous generation, but more especially on account of their remarkable zymogenic and pathogenic properties, so that Bacteriology has become one of the new sciences of the century.

Classification.

Having gained some idea of the number of species which have been recognised and described during the century, the next point for consideration is the progress made in the attempt to reduce this mass of material to such order that it can be intelligently apprehended; in a word, to convert a mass of facts into a science; "Filum ariadneum Botanices est systema, sine quo chaos est Res Herbaria" (Linnæus).

The classification of plants is a problem which has engaged attention from the very earliest times. Without attempting to enter into the history of the matter, I may just point out that, speaking generally, all the earlier systems of classification were more or less artificial, the subdivisions being based upon the distinctive features of one set of members of the plant. When I say that of all these systems that proposed by Linnæus (1735) was the most purely artificial, I do not imply any reproach: if it was the most artificial, it was at the same time the most serviceable, and its author was fully aware of its artificiality. This system is generally regarded as his most remarkable achievement; but the really great service which Linnæus rendered to science was the clear distinction which he for the first time drew between systems which are artificial and those which are natural. Recognising, as he did, his inability to frame at that period a satisfactory natural system, he also realised that with the increased number of known plants some more ready means of determining them was an absolute necessity, and it was for this purpose that he devised his artificial system, not as an end, but as a means. The end to be kept in view was the natural classification: "Methodus naturalis est ultimus finis Botanices" is his clearly expressed position in the "Philosophia Botanica."

There is a certain irony in the fact that the enthusiastic acceptance accorded to his artificial system throughout the greater part of Europe contributed to postpone the realisation of Linnæus's cherished hopes with regard to the attainment of a natural classification. It was just in those countries, such as Germany and England, where the Linnean system was most readily adopted that the development of the natural system proceeded most slowly. It was in France, where the Linnean system never secured a firm hold, that the quest of the natural system was pursued; and it is to French botanists more particularly that our present classification is due. It may be traced from its first beginnings with Magnol in 1689, through the bolder attempts of Adanson and of Bernard de Jussieu (1759), to the relatively complete method propounded by Antoine Laurent de Jussieu in his "Genera Plantarum," just 100 years later.

The nineteenth century opened with the struggle for predominance between the Jussiean and the Linnean systems. In England the former soon obtained considerable support, notably that of Robert Brown, whose "Prodromus Floræ Novæ Hollandiæ," published in 1810, seems to have been the first English botanical work in which the natural system was adopted; but it did not come into general use until it had been popularised by Lindley in the 'thirties.

Meantime the Jussiean system had been extended and improved by Auguste Pyrame de Candolle (1813–24). It is essentially the Candollean classification which is now most generally in use, and it has been immortalised by its adoption in Bentham and Hooker's "Genera Plantarum," one of the great botanical monuments of the century. In Germany, however, it has been widely departed from, the system there in vogue being based upon Brongniart's modification (1828, 1850) of de Candolle's method as elaborated successively by Alex. Braun (1864), Eichler (1876–83) and Prof. Engler (1886, 1898). It must be admitted that for the last fifty years the further evolution of the natural system, at any rate so far as Phanerogams are concerned, has been confined to Germany.

One of the most important advances in the classification of Phanerogams was based upon Robert Brown's discovery in 1827 of the gymnospermous nature of the ovule in Conifers and Cycads, which led Brongniart (1828) to distinguish these plants as "Phanérogames gymnospermes"; and although the systematic position of these plants has since then been the subject of much discussion, the recognition of the Gymnospermæ as a distinct group of archaic Phanerogams is now definitely accepted.

Moreover, the greatly increased knowledge of the Cryptogams has involved a considerable reconstruction in the classification of that great sub-kingdom. One of the most striking discoveries is that first definitely announced by Schwendener (1869) concerning Lichens, to the effect that the body of a Lichen consists of two distinct organisms, an Alga and a Fungus, living in symbiosis; a discovery which was so nearly made by other contemporary botanists, such as de Bary, Berkeley and Sachs, and which can be traced back to Haller and Gleditsch in the eighteenth century.

But the discoveries which most affected the classification of the Cryptogams are those relating to their reproduction. Whilst it had been recognised, almost from time immemorial, that Phanerogams reproduce sexually, sexuality was denied to Cryptogams until the observations on Liverworts and Mosses by Schmidel and by Hedwig (of whom it was said that he was born to banish Cryptogamy) in the eighteenth century; and even as late as 1828 we find Brongniart classifying the Fungi and Algæ together as "Agames." But in the middle third of the nineteenth century, by the labours of such men as Thuret, Pringsheim, Cohn, Hofmeister, Naegeli and de Bary, the sexuality of all classes of Cryptogams was clearly established. It is worthy of note that, although the sexuality of the Phanerogams had been accepted for centuries, yet the details of sexual reproduction were first investigated in Cryptogams. For it was not until 1823 that Amici discovered the pollen-tube, and it was more than twenty years later (1846) before he completed his discovery by ascertaining the true significance of the pollen-tube in relation to the development of the embryo; whilst it remained for Strasburger to observe, thirty years later, the actual process of fertilisation.

The discovery of the reproductive processes in Cryptogams not only facilitated a natural classification of them, but had the further very important effect of throwing light upon their relation to Phanerogams. Perhaps the most striking botanical achievement of the nineteenth century has been the demonstration by Hofmeister's unrivalled researches (1851) that Phanerogams and Cryptogams are not separated, as was formerly held, by an impassable gulf, but that the higher Cryptogams and the lower Phanerogams are connected by many common features.

The development of the natural classification, of which an account has now been given, proceeded for the most part on the assumption of the immutability of species. As Linnæus expressed it in his "Fundamenta Botanica," "species tot numeramus, quot diversæ formæ in principio sunt creatæ." It is difficult to understand how, with this point of view, the idea of affinity between species could have arisen at all; and yet the establishment of genera and the attempts at a natural system prove that the idea was operative. The nature of the prevalent conception of affinity is well conveyed by Linnæus's aphorism, "Affines conveniunt habitu, nascendi modo, proprietatibus, viribus, usu."

But a conviction had been gradually growing that the assumed fixity of species was not well founded, and that, on the contrary, species are descended from pre-existent species. This view found clear expression in Lamarck's "Philosophie Zoologique," published early in the century (1809), but it did not strongly affect public opinion until after the publication of Darwin's "Origin of Species" in 1859. Regarded from this point of view, the problems of classification have assumed an altogether different aspect. Affinity no longer means mere similarity, but blood-relationship depending upon common descent. We no longer seek a "system" of classification; we endeavour to determine the mutual relations of plants. The effect of this change has been to stimulate the investigation of plants in all their parts and in all stages of their life, so as to attain that complete knowledge of them without which their affinities cannot be accurately estimated. If the classification of Cryptogams is, at the present moment, in a more satisfactory position than that of Phanerogams, it is just because the study of the former group has been, for various reasons, more thorough and more minute than that of the latter.

Palaeophytology.

The stimulating influence of the new doctrine was not, however, confined to the investigation of existing plants; it also gave a remarkable impulse to the study of fossil plants, inasmuch as the theory of descent involves the quest of the ancestors of the forms that we now have around us. Marvellous progress has been made in this direction during the nineteenth century, by the labours more especially of Brongniart, Goeppert, Unger, Schimper, Schenck, Saporta, Solms-Laubach, Renault, on the Continent, and in our own country of Lindley and Hutton, Hooker, Carruthers, and more especially of Williamson. So far-reaching are the results obtained that I can only attempt the barest summary of them. I may perhaps best begin by saying that only a small proportion of existing species have been found in the fossil state. In illustration I may adduce the statement made by Mr. Clement Reid in his recent work, "The Origin of the British Flora," that only 270 species, that is, about one-sixth of the total number of British vascular plants, are known as fossils. Making all due allowances for the imperfection of the geological record, for the limited area investigated, and for the difficulty of determination of fragmentary specimens, it may be stated generally that the number of existing species has been found to rapidly diminish in the floras of successively older strata; none, in fact, have been certainly found to persist beyond the Tertiary period. Certain existing genera, belonging to the Gymnosperms and to the Pteridophyta, have, however, been traced far down into the Mesozoic period. Similarly, the distribution in time of existing natural orders does not coincide with that of existing genera; thus the Ferns of the Carboniferous epoch apparently belong, for the most part, if not altogether, to the order Marattiaceæ, but they are not referable to any of the existing genera.

Moreover, altogether new families of fossil plants have been discovered: such are, among Gymnosperms, the Cordaitaceæ and the Bennettitaceæ; among Pteridophyta, the Calamariaceæ, the Lepidodendraceæ, the Sphenophyllaceæ and the Cycadofilices. It is of interest to note that all these newly discovered families can be included within the main subdivisions of the existing flora; in fact, no fossil plants have been found which suggest the existence in the past of groups outside the limits of our Phanerogamia, Pteridophyta, Bryophyta and Thallophyta.

It cannot be said that the study of Palæobotany has as yet made clear the ancestry and the descent of our existing flora. To begin with the angiospermous flowering plants, it has been ascertained that they make their first appearance in the Cretaceous epoch, but we have no clue as to their origin. The relatively late appearance of Angiosperms in geological time suggests that they must have sprung from an older group, such as the Gymnosperms or the Pteridophyta; but there is no evidence to definitely establish either of these possible origins. Then as to the origin of the Gymnosperms, whilst it cannot be doubted that they were derived from the Pteridophyta, the existing data are insufficient to enable us to trace their pedigree. The most ancient family of Gymnosperms, the Cordaitaceæ, can be traced as far back as any known Pteridophyta, and cannot, therefore, have been derived from them; but the fact that the Cordaitaceæ exhibit certain cycadean affinities, and the discovery of the Cycadofilices, suggest that what may be termed the cycadean phylum of Gymnosperms (including the Cordaitaceæ, Bennettitaceæ, Cycadaceæ, and perhaps the Ginkgoaceæ) had its origin in a filicineous ancestry, of which, it must be admitted, no forms have as yet been recognised.

Turning to the Pteridophyta, the origin of the Ferns is still quite unknown: the one fact which seems to be clear is that the eusporangiate forms (Marattiaceæ) are more primitive than the leptosporangiate. With regard to the Equisetinæ, the Calamariaceæ were no doubt the ancestors of the existing and of the fossil Equisetums. Similarly, in the Lycopodinæ, the palæozoic Lepidodendraceæ were the forerunners of the existing Lycopodiums and Selaginellas. The discovery of the Sphenophyllaceæ seems to throw some further light upon the phylogeny of these two groups, inasmuch as these plants possess characters which indicate affinity with both the Equisetinæ and the Lycopodinæ, thus suggesting the possibility that they may have sprung from the same ancestral stock.

To complete the geological survey of the vegetable kingdom I will briefly allude to the Bryophyta and the Thallophyta. Owing no doubt to their delicate texture, the records of these plants have been found to be very incomplete. So much is this the case with the Bryophyta that I forbear to make any statement concerning them. The chief point of interest with regard to the Fungi is that most of those which have been discovered in the fossil state were found in the tissues of woody plants on which they were parasitic. In this way it has been possible to ascertain, with some probability, the existence of Bacteria and of mycelial Fungi in the Palæozoic period. The records of the Algæ are more satisfactory; they have been traced far back into the Palæozoic age, where they are represented by siphonaceous forms and by the somewhat obscure plants known as *Nematophycus* and *Pachytheca*.

In a general way the study of Palæobotany has proved the development of higher from lower forms in the successive geological periods. Thus the Tertiary and Quaternary periods are characterised by the predominance of Angiosperms, just as the Mesozoic period is characterised by the predominance of Gymnosperms, and the Palæozoic by the predominance of Pteridophyta. And yet, as I have been pointing out, we are not able to trace the ancestry of any one of the larger groups of plants. The chief reason for this is that the geological record, so far as it is known, has been found to break off with such surprising abruptness that the earliest, and therefore the most interesting, chapters in the evolution of plants are closed to us. After the wealth of plant-forms in the Carboniferous epoch there is a striking falling-off in the Devonian, in which, however, plants of high organisation, such as the Cordaitaceæ, the Calamariaceæ and the Lepidodendraceæ, still occur. In the Silurian epoch vascular plants are but sparingly present—but it is remarkable that any such highly organised plants should be found there—together with probable Algæ, such as *Nematophycus* and *Pachytheca*. The Cambrian rocks present nothing but so-called "Fucoids," such as *Eophyton*, &c., some of which may be Algæ. The only known fossil in the oldest strata of all, the Archæan, is the much-discussed *Eozoon canadense*, probably of animal origin; but the occurrence here of large deposits of graphite seems to indicate the existence of a considerable flora which has, unfortunately, become quite undeterminable. Thus, whilst there is some evidence that the primitive plants were Algæ, there is at present no available record of the various stages through which the Silurian and Devonian vascular plants were evolved from them.

Morphology.

If inquiry be made as to the cause of the great advance in the recognition of the true affinities of plants, and consequently in their classification, which distinguishes the nineteenth century, I would refer it to the progress made in the study of morphology. The earlier botanists regarded all the various parts of plants as "organs" in relation to their supposed function; hence their description of plants was simply "organography." The idea of regarding the parts of the plant-body, not in connection with their functions, but with reference to their development and their mutual relations, seems to have originated with Jung in the seventeenth century (1687): it was revived by C. F. Wolff about seventy years later (1759), but it did not materially affect the study of plants until well on in the nineteenth century, after Goethe had repeatedly written on the subject and had devised the term "morphology" to designate it. For a time this somewhat abstract mode of treatment led to mere theorising and speculation, so much so that the years 1820-1840 will always be stigmatised as the period of the "Naturphilosophie." But fortunately this time of barrenness was succeeded by a veritable renascence. Robert Brown and Henfrey in England; Brongniart, St. Hilaire and Tulasne in France; Mohl, Schleiden, Naegeli, A. Braun, and, above all, Hofmeister in Germany, led the way back from the pursuit of fantastic will-o'-the-wisps to the observation of actual fact. Instead of evolving schemes out of their own internal consciousness as to how plants ought to be constructed, they endeavoured to discover by the study of development, and more particularly of embryogeny, how they actually are constructed, with the result that within a decade Hofmeister discovered the alternation of generations in the higher plants; a discovery which must ever rank as one of the most brilliant triumphs of morphological research.

With the knowledge thus acquired it became possible to determine the true relations of the various parts of the plant-body; to distinguish these parts as "members" rather than as "organs"; in a word, to establish homologies where hitherto only analogies had been traced—which is the essential difference between morphology and organography.

The publication of the "Origin of Species" profoundly affected the progress or morphology, as of all branches of biological research: but it did not alter its trend; it confirmed and extended it. We are not satisfied now with establishing homologies, but we go on to inquire into the origin and phylogeny of the members of the body. In illustration I may briefly refer to two problems of this kind which at the present time are agitating the botanical world. The first is as to the origin of the alternation of generations. Did it come about by the modification of the sexual generation (gametophyte) into an asexual (sporophyte); or is the sporophyte a new formation intercalated into the life-history? In a word, is the alternation of generations to be regarded as homologous or as antithetic? I am not rash enough to express any opinion on this controversy; nor is it necessary that I should do so, since the subject has twice been threshed out at recent meetings of this Section. The second problem is as to the origin of the sphorophylls, and, indeed, of all the various kinds of leaves of the sporophyte in the higher plants. It is suggested, on the one hand, that the sporophylls of the Pteridophyta have arisen by gradual sterilisation and segmentation from an unsegmented and almost wholly reproductive body, represented in our day by the sporogonium of the Bryophyta; and that the vegetative leaves have been derived by further sterilisation from the sporophylls. On the other hand, it is urged that the vegetative leaves are the more primitive, and that the sporophylls have been derived from them. It will be at once observed that this second problem is intimately connected with the first. The sterilisation theory of the origin of leaves is a necessary consequence of the antithetic view of the alternation of generations; whilst the derivation of sporophylls from foliage-leaves is similarly associated with the homologous view. Here again, exercising a wise discretion, I will only venture to express my appreciation of the important work which has been done in connection with this controversy—work that will be equally valuable, whatever the issue may eventually be.

I will conclude my remarks on morphology with a few illustrations of the aid which the advance in this department has given to the progress of classification. For instance, Linnæus divided plants into Phanerogams and Cryptogams, on the ground that in the former the reproductive organs and processes are conspicuous, whereas in the latter they are obscure. In view of our increased knowledge of Cryptogams this ground of distinction is no longer tenable; whilst still recognising the validity of the division, our reasons for doing so are altogether different. For us, Phanerogams are plants which produce a seed; Cryptogams are plants which do not produce a seed. Again, we distinguish the Pteridophyta and the Bryophyta from the Thallophyta, not on account of their more complex structure, but mainly on the ground that the alternation of generations is regular in the two former groups, whilst it is irregular or altogether wanting in the latter. Similarly, the essential distinction between the Pteridophyta and the Bryophyta is that in the former the sporophyte, in the latter the gametophyte, is the preponderating form. It has enabled us further to correct in many respects the classifications of our predecessors by altering the systematic position of various genera, and sometimes of larger groups. Thus the Cycadaceæ have been removed from among the Monocotyledons, and the Coniferæ from among the Dicotyledons, where de Candolle placed them, and have been united with the Gnetaceæ into the sub-class Gymnospermæ. The investigation of the development of the flower, in which Payer led the way, and the elaboration of the floral diagram which we owe to Eichler, have done much, though by no means all, to determine the affinities of doubtful Angiosperms, especially among those previously relegated to the lumber-room of the Apetalæ.

Anatomy and Histology.

Passing now to the consideration of the progress of knowledge concerning the structure of plants, the most important result to be chronicled is the discovery that the plant-body consists of living substance indistinguishable from that of which the body of animals is composed. The earlier anatomists, whilst recognising the cellular structure of plants, had confined their attention to the examination of the cell-walls, and described the contents as a watery or mucilaginous sap, without determining where or what was the seat of life. In 1831 Robert Brown discovered the nucleus of the cell, but there is no evidence that he regarded it as living. It was not until the renascence of research in the 'forties, to which I have already alluded, that any real progress in this direction was made. The cell-contents were especially studied by Naegeli and by Mohl, both of whom recognised the existence of a viscous substance lining the wall of all living cells as a "mucous layer" or "primordial utricle," but differing chemically from the substance of the wall by being nitrogenous: this they regarded as the living part of the cell, and to it Mohl (1846) gave the name "protoplasm," which it still bears. The full significance of this discovery became apparent in a somewhat roundabout way. Dujardin, in 1835, had described a number of lowly organisms, which he termed Infusoria, as consisting of a living substance, which he called "sarcode." Fifteen years later, in a remarkable paper on *Protococcus pluvialis*, Cohn drew attention to the similarity in properties between the "sarcode" of the Infusoria and the living substance of this plant, and arrived at the brilliant generalisation that the "protoplasm" of the botanists and the "sarcode" of the zoologists are identical. Thus arose the great conception of the essential unity of life in all living things, which, thanks to the subsequent labours of such men as de Bary, Brücke, and Max Schultze, in the first instance, has become a fundamental canon of Biology.

A conspicuous monument of this period of activity is the cell-theory propounded by Schwann in 1839. Briefly stated, Schwann's theory was that all living bodies are built up of structural units which are the cells: each cell possesses an independent vitality, so that nutrition and growth are referable, not to the organism as a whole, but to the individual cells. This conception of the structure of plants was accepted for many years, but it has had to give way before the advance of anatomical knowledge. The recognition of cell-division as the process by which the cells are multiplied—in opposition to the Schleidenian theory of free cell-formation—early suggested doubts as to the propriety of regarding the body as being built up of cells as a wall is built of bricks. Later the minute study of the Thallophyta revealed the existence of a number of plants, such as the Myxomycetes, the phycomycetous Fungi, and the siphonaceous Algæ, some of them highly organised, the vegetative body of which does not consist of cells. It became clear that cellular structure is not essential to life; that it may be altogether absent or present in various degree. Thus in the higher plants the protoplasm is segmented or septated by walls into uninucleate units or "energids" (Sachs), and such plants are well described as "completely septate." But in others, such as the higher Fungi and certain Algæ (e.g. *Cladophora*, *Hydrodictyon*), the protoplasm is septated, not into energids, but into groups of energids, so that the body is "incompletely septate." Finally there are the Thallophyta already enumerated, in which there is complete continuity of the protoplasm: these are "unseptate." Moreover, even when the body presents the most complete cellular structure, the energids are not isolated, but are connected by delicate protoplasmic fibrils traversing the intervening walls; a fact which is one of the most striking discoveries in the department of histology. This was first recognised in the sieve-tubes by Hartig (1837); then by Naegeli (1846) in the tissues of the Florideæ. After a long period of neglect the matter was taken up once more by Tangl (1880), when it attracted the attention of many investigators, as the result of whose labours, especially those of Mr. Gardiner, the general and perhaps universal continuity of the protoplasm in cellular plants has been established. Hence the body is no longer regarded as an aggregate of cells, but as a more or less septated mass of protoplasm: the synthetic standpoint of Schwann has been replaced by one as distinctively analytic.

Time does not permit me to do more than mention the important discoveries made of late years, mainly on the initiative of Strasburger, with regard to the details of cytology, and especially to the structure of the nucleus and the intricate dance of the chromosomes in karyokinesis. Indeed, I can do but scant justice to those anatomical discoveries which are of more exclusively botanical interest. One important generalisation which may be drawn is that the histological differentiation of the plant proceeds, not in the protoplasm, as in the animal, but in the cell-wall. It is remarkable, on the one hand, how similar the protoplasm is, not only in different parts of the same body, but in plants of widely different affinities; and, on the other, what diversity the cell-wall offers in thickness, chemical composition, and physical properties. In studying the differentiation of the cell-wall the botanist has received valuable aid from the chemist. Research in this direction may, in fact, be said to have begun with Payen's fundamental discovery (1844) that the characteristic and primary chemical constituents of the cell-wall is the carbohydrate which he termed cellulose.

The amount of detailed knowledge as to the anatomy of plants which has been accumulated during the century by countless workers, among whom Mohl, Naegeli, Unger and Sanio deserve special mention as pioneers, is very great—so great, indeed, that it seemed as if it must remain a mere mass of facts in the absence of any recognisable general principles which might serve to marshal the facts into a science. The first step towards a morphology of the tissues was Hanstein's investigation of the growing point of the Phanerogams (1868), and his recognition therein of the three embryonic tissue-systems. This has lately been further developed by the promulgation of van Tieghem's theory of the stele, which is merely the logical outcome of Hanstein's distinction of the plerome. It has thus become possible to determine the homologies of the tissue-systems in different plants and to organise the facts of structure into a scientific comparative anatomy. It has become apparent that, in many cases, differences of structure are immediately traceable to the influence of the environment; in fact, the study of physiological or adaptive anatomy is now a large and important branch of the subject.

The study of Anatomy has contributed in some degree to the progress of systematic Botany. It is true that some of the more ambitious attempts to base classification on Anatomy have not been successful; such, for instance, as de Candolle's subdivision of Phanerogams into Exogens and Endogens, or the subdivision of Cormophyta into Acrobrya, Amphibrya, and Acramphibrya, proposed by Unger and Endlicher. Still it cannot be denied that anatomical characters have been found useful, if not absolutely conclusive, in suggesting affinities, especially in the determination of fossil remains. A large proportion of our knowledge of extinct plants, to which I have already alluded, is based solely upon the anatomical structure of the vegetative organs; and although affinities inferred from such evidence cannot be regarded as final, they suffice for a provisional classification until they are confirmed or disproved by the discovery and investigation of the reproductive organs.

Physiology.

The last branch of botanical science which I propose to pass in review is that of physiology. We may well begin with the nutritive processes. At the close of the eighteenth century there was practically no coherent theory of nutrition; such as it was it amounted to little more than the conclusion arrived at by van Helmont a century and a half earlier, that plants require only water for their food, and are able to form from it all the different constituents of their bodies. It is true that the important discovery had been made and pursued by Priestley (1772), Ingen-Housz (1780) and Sénébier (1782) that green plants exposed to light absorb carbon dioxide and evolve free oxygen; but this gaseous interchange had not been shown to be the expression of a nutritive process. At the opening of the nineteenth century (1804) this connection was established by de Saussure, in his classical "Recherches Chimiques," who demonstrated that, whilst absorbing carbon dioxide and evolving oxygen, green plants gain in dry weight; and he further contributed to the elucidation of the problem of nutrition by showing that, whilst assimilating carbon dioxide, green plants also assimilate the hydrogen and oxygen of water.

Three questions naturally arose in connection with de Saussure's statement of the case: What is the nature of the organic substance formed? What is the function of the chlorophyll? What is the part played by light? It was far on in the century before answers were forthcoming.

With regard to the first of these questions the researches of Boussingault (1864) and others established the fact that the volume of carbon dioxide absorbed and that of the oxygen evolved in connection with the process are approximately equal. Further, the frequent presence of starch in the chloroplastids, to which Mohl first drew attention (1837), was subsequently found by Sachs (1862) to be closely connected with the assimilation of carbon dioxide. The conclusion drawn from these facts is that the gain in dry weight accompanying the assimilation of carbon dioxide is due to the formation, in the first instance, of organic substance having the composition of a carbohydrate; a conclusion which may be expressed by the equation

$$CO_2 + H_2O = CH_2O + O_2.$$

The questions with regard to chlorophyll and to light are so intimately connected that they must be considered together. The first step towards their solution was the investigation of the relative activity of light of different colours, originally undertaken by Sénébier (1782) and subsequently repeated by Daubeny (1836), with the result that red and orange light was found to promote assimilation in a higher degree than blue or violet light. Shortly afterwards Draper (1843), experimenting with an actual solar spectrum, concluded that the most active rays are the orange and yellow; a conclusion which was generally accepted for many years. But in the meantime the properties of the green colouring matter of plants (to which Pelletier and Caventou gave the name "chlorophyll" in 1817) were being investigated. Brewster discovered in 1834 that an alcoholic extract of green leaves presents a characteristic absorption spectrum; but many years elapsed before any attempt was made to connect this property with the physiological activity of chlorophyll. It was not until 1871–72 that Lommel and N. J. C. Müller pointed out that the rays of the spectrum which are most completely absorbed by chlorophyll are just those which are most efficient in the assimilation of carbon dioxide. Subsequent researches, particularly those of Timiriazeff (1877), and those of Engelmann (1882–84) based on his ingenious Bacterium-method, have confirmed the views of Lommel and of Müller, and have placed it beyond doubt that the importance of light in the assimilatory process is that it is the form of kinetic energy necessary to effect the chemical changes, and that the function of chlorophyll is to serve as the means of absorbing this energy and of making it available for the plant.

These are perhaps the most striking discoveries in relation to the nutrition of plants, but there are others of not less importance to which brief allusion must be made. We owe to de Saussure (1804) the first clear demonstration of the fact that plants derive an important part of their food from the soil; but the relative nutritive value of the inorganic salts absorbed in solution was not ascertained until Sachs (1858) reintroduced the method of water-culture which had originated centuries before with Woodward (1699) and had been practised by Duhamel (1768) and de Saussure. Special interest centres around the question of the nitrogenous nutrition of plants. It was long held chiefly on the authority of Priestley and of Ingen-Housz, and in spite of the contrary opinion expressed by Sénébier, Woodhouse (1803) and de Saussure, that plants absorb the free nitrogen of the atmosphere by their leaves. This view was not finally abandoned until 1860, when the researches of Boussingault and of Lawes and Gilbert deprived it of all foundation. Since then we have learned that the free nitrogen of the air can be made available for nutrition—not indeed directly by green plants themselves, but, as Berthelot and Winogradsky more especially have shown, by Bacteria in the soil, or, as apparently in the Leguminosæ, by Bacteria actually enclosed in the roots of the plants with which they live symbiotically.

We now turn from the nutritive or anabolic processes to those which are catabolic. The discovery of the latter, just as of the former, was arrived at by the investigation of the gaseous interchange between the plant and the atmosphere. In the eighteenth century Scheele and Priestley had found that, under certain circumstances, plants deteriorate the quality of air; but it is to Ingen-Housz that we owe the discovery that plants, like animals, respire, taking in oxygen and giving off carbon dioxide. And when Sénébier (1800) had ascertained for the inflorescence of *Arum maculatum*, and later de Saussure (1822) for other flowers, that active respiration is associated with an evolution of heat, the connection between respiration and catabolism was established for plants as it had been long before by Lavoisier (1777) in the case of animals.

Among the catabolic processes which have been investigated none are of greater importance than those which are designated by the general term *fermentations*. The first of these to be discovered was the alcoholic fermentation of sugar. Towards the end of the seventeenth century Leeuwenhoek had detected minute globules in fermenting wort; and a century later Lavoisier had ascertained that the chemical process consists in the decomposition of sugar into alcohol and carbon dioxide; but it was not until 1837–38 that, almost simultaneously, Cagniard de Latour, Schwann and Kützing discovered that Leeuwenhoek's globules were living organisms, and were the cause of the fermentation. Shortly before, in 1833, Payen and Persoz extracted from malt a substance named *diastase*, which they found could convert the starch of the grain into sugar. These two classes of bodies, causing fermentative changes, were distinguished respectively as *organised* and *unorganised* ferments. The number of the former was rapidly added to by the investigation more especially of the Bacteria, in which Pasteur led the way. The extension of our knowledge of the unorganised ferments, or enzymes, has been even more remarkable; we now know that very many of the metabolic processes are effected by various enzymes, such as those which convert the more complex carbohydrates into others of simpler constitution (diastase, cytase, glucase, inulase, invertase); those which decompose glucosides (emulsin, myrosin, &c.); those which act on proteids (trypsins) and on fats (lipases); the oxidases, which cause the oxidation of various organic substances; and the zymase, recently extracted from yeast, which causes alcoholic fermentation.

The old distinction of the micro organisms as "organised ferments" is no longer tenable; for, on the one hand, certain of the chemical changes which they effect can be traced to extractable enzymes which they produce; and, on the other, as Pasteur has asserted, every living cell may become an "organised ferment" under appropriate conditions. The distinction now to be drawn is between those processes which are due to enzymes and those directly effected by living protoplasm. Many now definitely included in the former class were, until lately, regarded as belonging to the latter; and no doubt future investigation will still further increase the number of the former at the expense of the latter.

The consideration of the metabolic processes leads naturally to that of the function of transpiration and of the means by which water and substances in solution are distributed in the plant. This is perhaps the department of physiology in which progress during the nineteenth century has been least marked. We have got rid, it is true, of the old idea of an ascending crude sap, and of a descending elaborated sap, but there have been no fundamental discoveries. With regard to transpiration itself, we know more of the detail of the process, but that is all that can be said. As for root-pressure, Hofmeister (1858–82) discovered that "bleeding"—as the phenomena of root-pressure were termed by the earlier writers—is not confined, as had hitherto been thought, to trees and shrubs; but the current theory of the process, allowing for the discovery of protoplasm and of osmosis, has advanced but little upon that given by Grew in the third book of his "Anatomy of Plants" (1675). Again, the mechanism of the transpiration-current in lofty trees remains an unsolved problem. To begin with, there is still some doubt as to the exact channel in which the current travels. Knight (1801–8) first proved that the current travels in the alburnum of the trunk, but not, he thought, in the vessels, for he found them to be dry in the summer, when transpiration is most active; a view in which Dutrochet (1837) subsequently concurred. Meyen (1838) then suggested that the water must travel, not in the lumina, but in the substance of the cells of the vessels, and was supported by such eminent physiologists as Hofmeister (1858), Unger (1864, 1868) and Sachs (1878); but it has since been strongly asserted by Boehm, Elfving, Vesque, Hartig and Strasburger that the young vessels always contain water, and that the current travels in the lumina and not in the walls of the vessels.

Now as to the force by which the water of the transpiration-current is raised from the roots to the topmost leaf of a lofty tree. From the point of view that the water travels in the substance of the walls the necessary force need not be great, and would be amply provided by the transpiration of the leaves, inasmuch as the weight of the water raised would be supported by the force of imbibition of the walls. From the point of view that the water travels in the lumina, the force required to raise and support such long columns of water must be considerable. Dismissing at once as quite inadequate such purely physical theories as those of capillarity and gas-pressure, there remain two theories as to the nature of this force which resemble each other in being essentially vitalistic, but differ in that the one involves pressure from below, the other suction from above. In the one, suggested by Godlewski and by Westermaier (1884), the cells of the medullary rays and of the wood-parenchyma are supposed to absorb liquid from the vascular tissue at one level and force it back again by a vital act at a higher level: this theory was disposed of by the fact that the transpiration-current can be maintained through a considerable length of a stem killed by heat or by poison. In the other, suggested by Dixon and Joly (1895–99), and also by Askenasy (1895–96), it is assumed that there are, in the trunk of a transpiring tree, continuous columns of water which are in a state of tensile stress, the tension being set up by the vital transpiratory activity of the leaves. Some idea of the enormous tension thus assumed is given by the following simple calculation relating to a tree 120 feet high. Not only has the liquid to be raised to this height, but in its passage upwards a resistance calculated to be equal to about five times the height of the tree has to be overcome. Hence the transpiration-force in such a tree must at least equal the weight of a column of water 720 feet in height; that is, a pressure of about twenty-four atmospheres, or 360 lb. to the square inch. But there is no evidence to prove that a tension of anything like twenty atmospheres exists, as a matter of fact, in a transpiring tree; on the contrary, such observations as exist (*e.g.* those of Hales and of Boehm) indicate much lower tensions. Under these circumstances we must regretfully confess that yet one more century has closed without bringing the solution of the secular problem of the ascent of the sap.

The nineteenth century has been, fortunately, rather more fertile in discovery concerning the movements and irritability of plants. But it is surprising how much knowledge on these points had been accumulated by the beginning of the century: the facts of plant-movement, such as the curvatures due to the action of light, the sleep-movements of leaves and flowers, the contact-movements of the leaves of the sensitives, were all familiar. The nineteenth century opened, then, with a considerable store of facts; but what was lacking was an interpretation of them; and whilst it has largely added to the store, its most important work has been done in the direction of explanation.

The first event of importance was the discovery by Knight, in 1806, of the fact that the stems and roots of plants are irritable to the action of gravity and respond to it by assuming definite directions of growth. Many years later the term "geotropism" was introduced by Frank (1868) to designate the phenomena of growth as affected by gravity, and at the same time Frank announced the important discovery that dorsiventral members, such as leaves, behave quite differently from radial members, such as stems and roots, in that they are diageotropic

It was a long time before the irritability of plants to the action of light was recognised. Chiefly on the authority of de Candolle (to whom we owe the term "heliotropism"), heliotropic curvature was accounted for by assuming that the one side received less light than the other, and therefore grew the more rapidly. But the researches of Sachs (1873) and Müller-Thurgau (1876) have made it clear that the direction of the incident rays is the important point, and that a radial stem, obliquely illuminated, is stimulated to curve until its long axis coincides with the incident rays. Moreover, the discovery by Knight (1812) of negative heliotropism in the tendrils of *Vitis* and *Ampelopsis* really put the Candollean theory quite out of court; and further evidence that heliotropic movements are a response to the stimulus of the incident rays of light is afforded by Frank's discovery of the diaheliotropism of dorsiventral members.

The question of the localisation of irritability has received a good deal of attention. The fact that the under surface of the pulvinus of *Mimosa pudica* is alone sensitive to contact was ascertained by Burnett and Mayo in 1827; and shortly after (1834) Curtis discovered the sensitiveness of the hairs on the upper surface of the leaf of *Dionaea*. After a long period of neglect the subject was taken up by Darwin. The irritability of tendrils to contact had been discovered by Mohl in 1827; but it was Darwin who ascertained, in 1865, that it is confined to the concavity near the tip. In 1875 Darwin found that the irritability of the tentacles of *Drosera* is localised in the terminal gland; and followed this up, in 1880, by asserting that the sensitiveness of the root is localised in the tip, which acts like a brain. This assertion led to a great deal of controversy, but the researches of Pfeffer and Czapek (1894) have finally established the correctness of Darwin's conclusion. It is interesting to recall that Erasmus Darwin had suggested the possible existence of a brain in plants in his "Phytologia" (1800). But the word "brain" is misleading, inasmuch as it might imply sensation and consciousness: it would be more accurate to speak of centres of ganglionic activity. However, the fact remains that there exist in plants irritable centres which not only receive stimuli but transmit impulses to those parts by which the consequent movement is effected. The transmission of stimuli has been found in the case of *Mimosa pudica* to be due to the propagation of a disturbance of hydrostatic equilibrium along a special tissue; in other cases, where the distance to be traversed is small, it is probably effected by means of that continuity of the protoplasm to which I have already alluded.

Finally, as regards the mechanism of these movements, we find Sénebier and Rudolphi, the earliest writers on the subject in the nineteenth century, asserting, as if against some accepted view, that there is no structure in a plant comparable with the muscle of an animal. Rudolphi (1807) suggested, as an alternative, that the position of a mobile leaf is determined by the "turgor vitalis" of the pulvinus, and thus anticipated the modern theory of the mechanism. But he gives no explanation of what he means by "turgor"; and the term is frequently used by writers in the first half of the century in the same vague way. Some progress was made in consequence of the discovery of osmosis by Dutrochet (1828), and more especially by his observation (1837) that the movements of *Mimosa* are dependent on the presence of oxygen, and are therefore vital. But it was not, and could not be, until the existence of living protoplasm in the cells of plants was realised, and the movements of free-swimming organisms and naked reproductive cells had become more familiar, that the true nature of the mechanism began to be understood; and then we find Cohn saying, as long ago as 1860, that "the living protoplasmic substance is the essentially contractile portion of the cell." This statement may, perhaps, seem to put the case too bluntly, and to savour too much of animal analogy; but the study of the conditions of turgidity has shown more and more clearly that the protoplasm is the predominant factor. The protoplasm of plant-cells is undoubtedly capable of rapid molecular changes, which alter its physical properties, more particularly its permeability to the cell-sap. It may be that these changes cannot be directly compared with those going on in animal muscle; but if we use the term "contractility" in its wider sense, as indicating a general property of which muscular contraction is a special case, then Cohn's statement is fully justified. This is borne out by the observations of Sir J. Burdon-Sanderson (1882–88) on the electrical changes taking place in the stimulated leaf of *Dionaea*, and by Kunkel's (1878) corresponding observations on *Mimosa pudica*: in both cases the electrical changes were found to be essentially the same as those observable on the stimulation of muscle. We find, then, that the advances in Physiology, like those in Anatomy, teach the essential unity of life in all living things, whether we call them animals or plants.

With this in our minds we may go on to consider in conclusion, and very briefly, that department of physiological study which is known as the Bionomics of Œcology of plants. In the earlier part of the century this subject was studied more especially with regard to the distribution of plants, and their relation to soil and climate; but since the publication of the "Origin of Species" the purview has been greatly extended. It then became necessary to study the relation of plants, not only to inorganic conditions, but to each other and to animals; in a word, to study all the adaptations of the plant with reference to the struggle for existence. The result has been the accumulation of a vast amount of most interesting information. For instance, we are now fairly well acquainted with the adaptations of water-plants (hydrophytes) on the one hand, and of desert-plants (xerophytes) on the other; with the adaptations of shade-plants and of those growing in full sun, especially as regards the protection of the chlorophyll. We have learned a great deal as to the relations of plants to each other, such as the peculiarities of parasites, epiphytes and climbing plants, and as to those singular symbioses (Mycorhiza) of the higher plants with Fungi which have been found to be characteristic of saprophytes. Then, again, as to the relations between plants and animals: the adaptation of flowers to attract the visits of insects, first discovered by Sprengel (1793), has been widely studied; the protection of the plant against the attacks of animals, by means of thorns and spines on the surface, as also by the formation in its tissues of poisonous or distasteful substances, and even by the hiring of an army of mercenaries in the form of ants, has been elucidated; and finally those cases in which the plant turns the tables upon the animal, and captures and digests him, are now fully understood.

Conclusion.

Imperfect as is the sketch which I have now completed, it will, I think, suffice to show how remarkable has been the progress of the science during the nineteenth century, more particularly the latter part of it, and how multifarious are the directions in which it has developed. In fact Botany can no longer be regarded as a single science; it has grown and branched into a congeries of sciences. And as we botanists regard with complacency the flourishing condition of the science whose servants we are, let us not forget, on the one hand, to do honour to those whose life work it was to make the way straight for us, and whose conquests have become our peaceful possession; nor, on the other, that it lies with us so to carry on the good work that when this Section meets a hundred years hence it may be found that the achievements of the twentieth century do not lag behind those of the nineteenth.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

As was explained at length in our issue of March 22, in accordance with the new statutes of the University of London, a reconstituted Senate is to be elected shortly. The new Senate will be composed of the Chancellor, the Chairman of Convocation and fifty-four Senators, of whom sixteen are to be elected by Convocation. These sixteen members of the Senate will have, it would appear from the statutes, two distinct functions. They will, in addition to their general duties as senators, be required to form a special council for external students. This council, which is to consist of twenty-eight members of the Senate, will include the chancellor, the vice-chancellor, the chairman of Convocation, the sixteen senators elected by Convocation, and nine other members of the Senate elected by the Senate. Members of Convocation will, in a few days, proceed to choose their sixteen representatives; and, not unnaturally, there is considerable diversity of opinion as to the suitability of the nominated candidates. Two rival associations have sprung up. One body of graduates insists that the duties to be performed upon the council for external students should be considered of paramount importance in electing senators; the other, that their responsibilities as members of the Senate should be kept continually in view, because the work of the new University as a whole, but more especially the development of its teaching facilities, is of the most pressing nature. While admitting the necessity of safe-guarding the interests of the external student, and of ensuring the high value of the degrees of the University, it is desirable that every possible means of improving the higher education of London should receive primary consideration. It would be nothing less than a calamity were Convocation to elect sixteen irreconcilables with no ideas outside that of introducing the peculiar, though somewhat circumscribed, needs of the external student into all deliberations of the Senate. It is therefore to be hoped that the common-sense which attended the election of their representative in Parliament will characterise the selection of the sixteen senators chosen by Convocation. It is easily possible to find members of the University who, while fully aware of the needs, and in sympathy with the aims of the external student, have also broad views as to the work of a great teaching University.

DR. A. P. LAURIE, lecturer in physics and chemistry at St. Mary's Hospital Medical School, has been appointed principal of the Heriot Watt College, Edinburgh.

DR. SPENCER W. RICHARDSON, lecturer on physics at the University College, Nottingham, has been appointed principal and professor of physics at the Hartley College, Southampton.

THE Birkbeck Institution, London, which has now completed seventy-seven years of educational work in the metropolis, commences its new session on Monday, October 1. The Institution has had many additions to its appliances in recent years, and the physical, chemical and metallurgical laboratories are now very thoroughly equipped. The day classes provide courses in chemistry, biology, physics and mathematics for the science degrees of London University. During the recess considerable additions and improvements have been made by the aid of a gift of 2000 guineas from Mr. F. Ravenscroft, to commemorate his completion of a membership of fifty years.

ADDRESSES will be given at the opening of many of the metropolitan and provincial medical schools at the beginning of October. At Middlesex Hospital on October 1, Dr. T. Clifford Allbutt, F.R.S., will distribute the prizes gained during the previous year and deliver an address. At St. George's Hospital the introductory address will be delivered by Dr. Francis G. Penrose. At University College the session of the faculty of medicine will be opened by Prof. G. Vivian Poore; the session of the faculty of arts and laws, and of science, will be opened with an address by Prof. F. W. Oliver on October 2. At St. Mary's Hospital the introductory address will be given by Mr. H. S. Collier. At St. Thomas's Hospital the session will open on Tuesday, October 2, when the prizes will be distributed by Sir William MacCormac. At the opening of the session at Charing Cross Hospital on October 2, Lord Lister will deliver the third biennial Huxley Lecture. The London School of Tropical Medicine will open on October 1, and the introductory address will be delivered by Sir William MacGregor, K.C.M.G., C.B., on Wednesday, October 3. At the London School of Medicine for Women the introductory address will be given on October 1 by Miss Aldrich Blake, M.S., M.D., after which the prizes for the past year will be distributed. At the Royal Veterinary College the introductory address will be delivered by Prof. McFadyean. The winter session at the University of Birmingham will begin on October 1 with an address by Prof. B. C. A. Windle. At University College of South Wales and Monmouthshire, Cardiff, the address will be delivered on October 1 by Sir John Williams. At University College, Liverpool, the Bishop of Liverpool will deliver an address on October 13 and distribute the prizes.

A SUMMARY of the scheme of work carried on by the Essex Technical Instruction Committee for the promotion of interest in the science of agriculture and other branches of knowledge bearing upon rural industries, has been prepared by Messrs. T. S. Dymond and J. H. Nicholas. The work is in every respect satisfactory, and should do much to broaden the views of the practical farmers of the county as to the value of agricultural education and experiment. Every year an educational excursion extending over several days is organised, the one this year being to Denmark to study dairy farms and dairying, high school and agricultural education, co-operation and organisation of agricultural industry there. Field experiments are carried out by arrangement with farmers distributed in all parts of the county, the advantage being that as demonstrations of the effect of manures, &c., they receive wider attention, and also that the experiments can be made on each of the different classes of land occurring in the county. Meetings of farmers are held in the experimental fields in each district at the season most suitable for studying the results of the experiments. The County Technical Laboratories at Chelmsford are now recognised as a centre from which information upon agricultural matters can be obtained. The advice of the staff is frequently sought on insect and fungoid pests, on difficulties met with in the dairy, &c., and their opinion asked on the value of foods and of fertilisers, and the best manurial treatment of land. As occasion arises, inquiries are undertaken on matters of agricultural importance, such as the chemical and physical effect of the salt water inundation upon agricultural land on the coast of Essex, and the best method for its amelioration. The agricultural work of the Essex Technical Instruction Committee is thus of the same character as that carried on by the Government